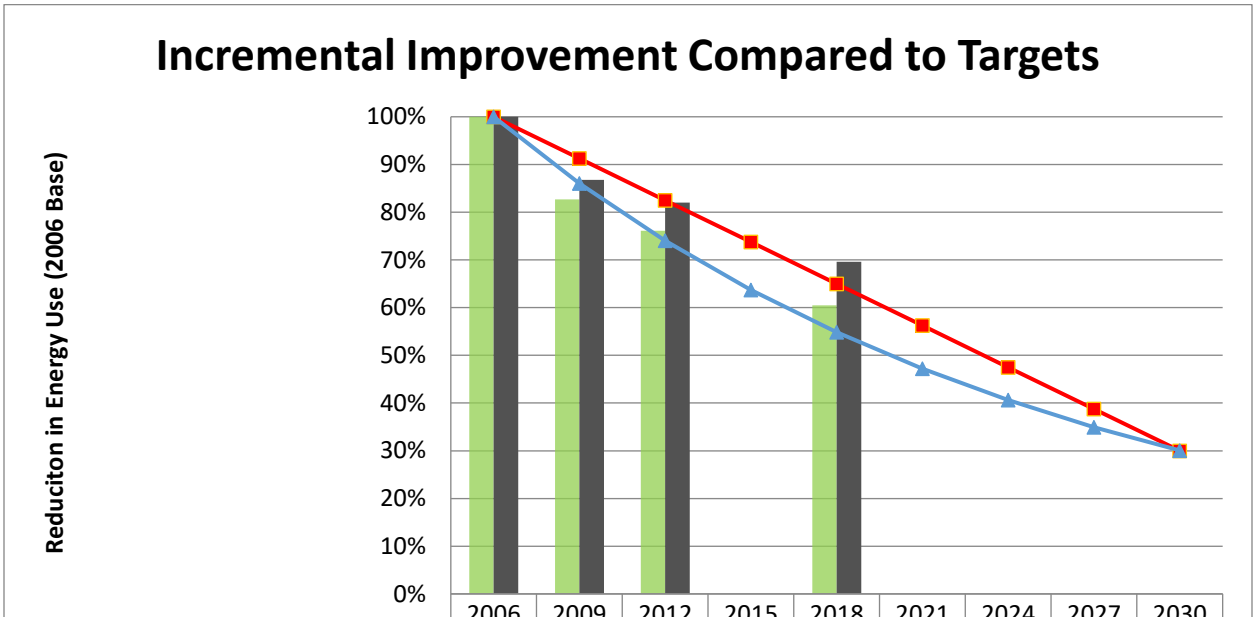
Preliminary Cost Benefit Analysis for the 2021 Washington State Energy Code, Residential Provisions

I. Code Adoption and Significant legislative Rules

1. Introduction

The legislature finds making homes, businesses, and public institutions more energy efficient will save money, create good local jobs, enhance energy security, reduce pollution that causes global warming, and speed economic recovery while reducing the need to invest in costly new generation. The State Energy Code Act, RCW 19.27A, sets forth the statutory authority and goals for the adoption and amendment of the Washington State Energy Code. The primary goals are to construct increasingly energy efficient homes and buildings that help achieve the broader goal of building zero fossil-fuel greenhouse gas emission homes and buildings by the year 2031 [*RCW 19.27A.020 (2)(a)*], any amendments must increase the energy efficiency of typical newly constructed nonresidential buildings [*RCW 19.27A.025(1)(a)*], and amendments shall incrementally move towards achieving a seventy percent reduction in annual net energy consumption by 2031 [*RCW 19.27A.160*]. To achieve the required seventy percent reduction, the Washington State Building Code Council (SBCC) established two models for measuring incremental change. One was to target an 8.75 percent reduction each three-year code cycle compared to the 2006 code. The other pathway is a 14 percent reduction over the previous code.



	2006	2009	2012	2015	2018	2021	2024	2027	2030
Residential	100%	82.7%	76.1%		60.5%				
Commercial	100%	86.8%	82.0%		69.6%				
Target: 8.75 % savings compared to the 2006 WSEC	100%	91%	83%	74%	65%	56%	48%	39%	30%
Target: 14% savings compared to each previous code	100%	86%	74%	64%	55%	47%	41%	35%	30%

Based on the report of the progress made with the 2018 code towards the 70 percent reduction, a 19 percent reduction over the previous code was identified to place the commercial portions of the code

back on track to attain the targeted reduction for the 2021 code. Stakeholders were asked to submit proposals to help attain this reduction goal.

The Residential Portion of the energy code, which is the topic of this cost benefit analysis, covers residential buildings including single family homes, townhouses, and multi−family dwelling unit buildings that are three stories and less. The Commercial Portion of the energy code covers all non−residential buildings, residential dwelling unit buildings that are four stories and more, and all residential sleeping unit buildings regardless of the number of stories.

The International Energy Conservation Code is the base document for the development of the Washington State Energy Code and this national model code is updated every three years. Those updates that further the statutory goals set forth in RCW 19.27A are integrated with the existing WAC 51-11R language and published as a basis for stakeholders to submit code change proposals.

2. Adoption of 2021 Washington State Energy Code, Residential Provisions.

The Washington State Building Code Council (SBCC) filed the Preproposal Statement of Inquiry to initiate the development of the 2021 Washington State Energy Code, Commercial Provisions, as adopted through WAC 51-11R, on January 10, 2022. In considering amendments to the state energy code, the Council established and consulted with a technical advisory group (TAG) including representatives of appropriate state agencies, local governments, general contractors, building owners and managers, design professionals, utilities, and other interested and affected. On February 1, 2022, the SBCC opened a submittal period for proposals for the 2021 Washington State Energy Code, Commercial provisions.

The Council has adopted a definition of cost−effectiveness based on RCW 39.35 as recommended by Department of Commerce. A guide on how to evaluate cost−effectiveness is therefore defined by the Council as a code change that has a net present savings over a 50−year life−cycle of a building utilizing the Life Cycle Cost Tool (LCCT) as developed by the Washington State Office of Financial Management (OFM). The methodology of the LCCT is based on the NIST Handbook 135 methodology and utilizes specific inputs as determined by the Council with guidance from the Washington State Department of Commerce[1]. The cost effectiveness analysis uses the average useful life years from Appendix 7 of the BOMA Preventive Maintenance Guidebook for all building components that are evaluated[2]. An alternate method of cost effectiveness analysis or determining average useful life years of building components may be applied. Each code change submitted that is not editorial or explanatory is required to include this analysis.

The TAG was also tasked with reviewing the proposals received, identifying pros and cons and whether it helped achieve the broader goals of energy savings and emission reduction. The TAG also discussed whether modifications were needed to ensure the provisions were correlated with other requirements, technically feasible, commercially available, and cost−effective to building owners and tenants, or if changes were necessary to mitigate any disproportionate impact on small business.

44 proposals were submitted during the two-month submittal period. After hundreds of hours of discussions, the TAG recommended that 29 proposals move forward into the rulemaking process. Most of these proposals are exempt from the cost benefit analysis requirement of 34.05.328 as they are

[1] http://www.ofm.wa.gov/budget/facilities/costanalysis.asp
[2] https://icap.sustainability.illinois.edu/files/projectupdate/2289/Project% 20Lifespan%20Estimates.pdf

editorial or provide additional clarity to existing rules. Additionally, changes coming from the national model code process (International Energy Conservation Code) are also exempt from the requirements of RCW 34.05.328 and not addressed here. Ultimately eight proposals were identified as having more than a minimal cost impact. Seven proposals were identified as having minimal impact. The remaining 14 proposals were either clarifying requirements, correlating code requirements, or had minimal impact. Those with minimal impact are highlighted in Table 1.

TABLE 1
Code Change Proposals with Minimal Economic Impact

Code Change	Section/Description	Cost/Energy Savings
21-GP2-035	**R502.3.1.1** Existing ceilings with attic spaces This new section requires that when additions over 150 square feet adjoin existing attic spaces, the existing attic space needs to be brought into full compliance with the envelope provisions in R402.	This proposal was tied to the new exception exempting additions less than 150 square feet from Section C406 compliance. This particular measure was not evaluated separately for costs and energy savings. There would be an added cost based on the square footage of existing attic space needing to be upgraded. Estimated cost is between $0.80 and $2.60 per square foot. Estimated annual energy savings is approximately 0.6 percent.
21-GP2-088	**R402.4.1.2** Testing The specifics on the testing standard were moved from the exception into the main body of the section and the test must include information on the time, date and location where performed. Requirements were also added that the testing personnel be trained by an accredited program. The second exception from the second set of exceptions was moved to Section R402.4.1.3. The volume adjustment capping the ceiling height at 8.5 feet was removed.	There was some debate at the TAG as to whether there would be a cost associated with this measure, focusing on the requirement for training from an accredited program. Ultimately, it was determined that there would be little to no increase. There are no energy savings associated with this proposal, other than ensuring proper testing to achieve the originally intended savings.
The following proposals add options to the menu of additional energy efficiency credits to be selected. These are optional items that may be selected as part of the package for the required credits.		
21-GP2-023	**Table R406.3** Energy credits Option 3.2 requires a cold climate heat pump to be used in areas with a winter design temperature at 23° or below.	Cost: Estimated incremental cost is $1000 per dwelling unit. Energy savings: Estimated annual energy savings of 4,000 kWh, or $400 per year.
21-GP2-024	**Table R406.3** Energy credits Option 3.5 allows an alternate cold climate 10 HSPF heat pump to be substituted for an 11 HSPF heat pump but will require a cold climate heat pump similar to Option 3.2 in 023, above.	Cost: Estimated incremental cost is $1500 per dwelling unit. Energy savings: Estimated annual energy savings of 4,000 kWh, or $400 per year.

Code Change	Section/Description	Cost/Energy Savings
21-GP2-025	**Table R406.3** Energy credits Option 3.6 also allows a substitution of a 9 HSPF heat pump for the required 10 HSPF in some cases.	Cost: Estimated incremental cost is $1500 per dwelling unit. Energy savings: Negligible for single zone systems, but significant for multi-zone systems.
21-GP2-050	**Table R406.3** Energy credits New Option 3.7 provides credit for an air to water heat pump with a COP rating of 3.2.	Cost: Estimated incremental cost is $4000 per dwelling unit. Energy savings: Estimated annual energy savings of 6,000 to 12,000 kWh, or $700 to $1400 per year.
21-GP2-034	**Table R406.3** Energy credits New Option 3.8 allows a half credit for a connected thermostat.	Cost: Estimated incremental cost is $200 per dwelling unit. Energy savings: Estimated annual energy savings of 600 kWh, or $60 per year.

II. Code Proposals Identified as Significant.

1. Summary of Probable Benefits vs Probable Costs.

Code proposals identified as significant are identified in Table 2 and are detailed below.

TABLE 2
Code Change Proposals Marked as Significant Impact

Proposal Number	Subject	Proponent	Link to Initial Proponent Cost Benefit Analysis
21-GP2-065	Heat Pump Space Heating	Sean Denniston	Proponent's Cost Benefit Analysis Supplemental revised analysis
21-GP2-066	Heat pump Water Heating	Sean Denniston	Proponent's Cost Benefit Analysis Supplemental revised analysis
21-GP2-084	Definition of Residential Building	Duane Jonlin	Proponent's Cost Benefit Analysis
21-GP2-079	Window U-factor	Dan Wildenhaus	Proponent's Cost Benefit Analysis
21-GP2-073 Option 1 Option 2	Additional Efficiency Credits/Fuel Normalization	Henry Odem	Proponent's Cost Benefit Analysis
21-GP2-089	Maximum Air Leakage Rate	Lisa Rosenow	Proponent's Cost Benefit Analysis
21-GP2-080	Water Heater Location	Nick O'Neil	Proponent's Cost Benefit Analysis
21-GP2-032	Sealed Air Handler Location	WSU Energy Program	Proponent's Cost Benefit Analysis

1.1 Heat Pump Space Heating, Proposal 21-GP2-065, adding a new section WAC 51-11R-40392 and modifying existing sections 51-11R-40551 and 51-11R-50300

Brief Description: This requires that space heating be provided by a heat pump—either gas or electric—as a method to reduce greenhouse gas emissions and save energy. There are exceptions provided for dwellings with small heating loads and allowances for supplementary heating following the requirements of Section R403.1.2. Replacement heating equipment is not required to comply with the heat pump requirement as long as it does not exceed the heating capacity of the equipment being replaced.

Purpose of code change: Requiring space heating to be all-electric eliminates a significant source of fossil fuel combustion in buildings and is generally 2-4 times more energy efficient than either fossil fuel or electric resistance heating. This proposal aligns with State policy in RCW 19.27A.160 to increase energy efficiency by 70 percent by 2031. Additionally, this proposal will significantly reduce emissions and is aligned with State policy in RCW 19.27A.020 to achieve the broader goal of building zero fossil-fuel greenhouse gas emission homes and buildings by the year 2031. According to analysis done using data from the 2021 Washington State Energy Strategy, we need to reduce the commercial buildings sector emissions by 44 percent to keep on track to meet our 2050 climate goals. To achieve this, the State will need to double the proportion of annual sales of heat pumps from 21 percent of all residential space heating equipment in 2020 to 39 percent by 2030. To get to this increase in market penetration of heat pumps, the Washington State Energy Code should require heat pump space heating in the 2021 code cycle. See Supplemental Attachment[3][4] for further details on emissions and market penetration.

Review Process: The TAG spent several 6-hour meetings reviewing this proposal. It was sent back several times to be revised and reviewed by workgroups, including the proponent and key stakeholders. Through these workgroups and TAG review, modifications were suggested and made to help mitigate impact on small business. Modifications also allowed the use of gas heat pumps.

Probable Benefits vs probable costs: Construction costs for heat pump space heating are often, but not always, higher than for conventional natural gas or electric resistance heating. When eliminating the cost of gas infrastructure running to the building and the cost of a separate air conditioner for space cooling, all-electric homes are generally less expensive than mixed fuel homes. Annual energy costs for heat pump space heaters are much lower than for electric resistance heating, but comparable with gas heating, at current rates (World Bank long term forecasts indicate an increase of over 80 percent in gas prices over the coming decade.) When including the Washington State social cost of carbon, heat pump space heating is more cost effective than both gas heating and electric resistance heating over the life cycle analysis horizon.

The average life cycle cost savings of $1.14 per square foot and $4.57 per square foot when including the social cost of carbon. See Supplemental Attachment (footnotes 3and 4) for more details. Total annual energy savings is estimated at 5.5 kBtu per square foot.

[3] https://sbcc.wa.gov/sites/default/files/2022-09/065R_HP_Space_cba.pdf
[4] https://sbcc.wa.gov/sites/default/files/2022-06/Supplemental_Amended%20Analysis_Kocher_060122.pdf

Life Cycle Cost Analysis				
Alternative	**Mixed-fuel Building (Baseline)**	**All-Electric Building Proposal**	**Heat Pump Water Heating Proposal**	**Heat Pump Space Heating Proposal**
Energy Use Intenstity (kBtu/sq.ft)	24.4	15.0	21.2	18.9
% Energy Reduction	N/A	39%	13%	22%
1st Construction Costs	$16,411	$13,402	$17,057	$13,686
PV of Capital Costs	$34,752	$32,318	$36,563	$28,959
PV of Utility Costs	$32,319	$28,890	$31,182	$29,920
Total Life Cycle Cost (LCC)	**$ 67,071**	**$ 61,208**	**$ 67,745**	**$ 58,879**
Net Present Savings (NPS)	**N/A**	**$ 5,864**	**$ (674)**	**$8,192**
Tons of CO2e over Study Period	108	30	81	64
% CO2e Reduction vs. Baseline	N/A	72%	25%	40%
Present Social Cost of Carbon (SCC)	$ 7,191	$ 2,242	$ 5,502	$ 4,410
Total LCC with SCC	**$ 74,263**	**$ 63,450**	**$ 73,247**	**$ 63,288**
NPS with SCC	**N/A**	**$ 10,813**	**$ 1,016**	**$ 10,974**

Energy Analysis:

	Site Energy Use (MMBtu/yr)			
End Use	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating***	**Heat Pump Space Heating***
Misc. (E)	9.1	9.1	9.1	9.1
Vent Fan (E)	2	2	2	2
Lg. Appl. (E)	6.5	8.06	6.5	6.5
Lights (E)	6.77	6.77	6.77	6.77
Cooling Fan/Pump (E)	0.39	0.08	0.39	0.08
Heating Fan/Pump (E)	0.53	0.15	0.53	0.15
Cooling (E)	0.98	0.73	0.98	0.73
Heating (E)	0	5.58	0	5.58
Heating (G)	17.78	0	17.78	0
Hot Water (E)	0.15	2.88	2.88	0.15
Hot Water, Suppl. (E)	0	0.56	0.56	0
Hot Water (G)	10.97	0	0	10.97
Lg. Appl. (G)	3.33	0	3.33	3.33
Total	58.5	35.9	50.82	45.36

	Site Energy Use (MMBtu/yr)			
Fuel	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating**	**Heat Pump Space Heating**
Electricity	26.4	35.9	29.7	31.1
Natural gas	32.1	0.0	21.1	14.3
Total	58.5	35.9	50.8	45.4

	Site Energy Use			
Fuel	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating**	**Heat Pump Space Heating**
Electricity (kWh)	7,743	10,524	8,707	9,103
Natural gas (therms)	321		211	143

	Utility Costs (Electricity Rate = $0.0856/kWh & Gas Rate = $0.818/therm)			
Fuel	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating**	**Heat Pump Space Heating**
Electricity (kWh)	$ 662.80	$ 900.87	$ 745.33	$ 779.20
Natural gas (therms)	$ 262.48	$	$ 172.72	$ 117.00

1.2 Heat Pump Water Heating, Proposal 21-GP2-066, modifying existing sections WAC 51-11R-40340, 51-11R-40551 and 51-11R-50300

Brief Description: This requires that service water heaters in single family dwellings, duplexes and townhouses be provided by heat pump water heaters. Exceptions are provided for small water heaters, small dwelling units, supplemental water heating systems, and some renewable energy systems. This includes allowances for both gas and electric heat pump water heaters. Replacement water heating equipment is not required to comply with the heat pump requirement as long as it does not exceed the heating capacity of the equipment being replaced

Purpose of code change: Heat pump water heating eliminates a significant source of fossil fuel combustion in buildings and is generally 2-4 times more energy efficient than either fossil fuel or electric resistance heating. This proposal aligns with state policy to increase energy efficiency by 70 percent by 2031. Additionally, this proposal will significantly reduce emissions, aligned with state policy to achieve the broader goal of building zero fossil-fuel greenhouse gas emission homes and buildings by the year 2031. According to analysis done on data from the 2021 Washington State Energy Strategy, we would need to reduce the commercial buildings sector emissions by 44 percent to keep on track to meet our 2050 climate goals. To achieve this, the state will need to dramatically increase the proportion of annual sales of heat pump water heaters from 0.4 percent of all residential water heating equipment in 2020 to 55 percent by 2030. To get to this increase in market penetration of heat pump water heaters, the Washington State Energy Code should require all residential water heating to be all-electric in the 2021 code cycle.

Review Process: The TAG spent several meetings reviewing this proposal, and it was sent back several times to be revised and reviewed by workgroups, including the proponent and key stakeholders. Through these workgroups and TAG review, modifications were suggested and made to help mitigate impact on small business, and to clarify and simplify the language. Modifications also allowed the use of gas heat pump water heaters. There are also options within Section C406 affected by this measure. Some existing credit options were eliminated; however, other options have been proposed to keep the menu of options broad.

Probable Benefits vs probable costs: The estimated incremental cost for this proposal is $646 per dwelling, or $0.27 per square foot. The proposal will have a life cycle cost increase of $0.28 per square foot when not accounting for the social cost of carbon. When accounting for the adjusted social cost of carbon, the heat pump water heater proposal will have a $0.42 per sq ft savings. The average energy savings will be approximately 3.2 kBtu per square foot, or approximately 7,680 kBtu per dwelling. There is no anticipated increase in plan review or inspection time.

Benefits to building owners include improved air quality, reduced greenhouse gas emission and lower annual energy costs for water heating. This also aligns with the state's climate goals and policy.

Life Cycle Cost Analysis				
Alternative	**Mixed-fuel Building (Baseline)**	**All-Electric Building Proposal**	**Heat Pump Water Heating Proposal**	**Heat Pump Space Heating Proposal**
Energy Use Intenstity (kBtu/sq.ft)	24.4	15.0	21.2	18.9
% Energy Reduction	N/A	39%	13%	22%
1st Construction Costs	$16,411	$13,402	$17,057	$13,686
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PV of Utility Costs	$32,319	$28,890	$31,182	$29,920
Total Life Cycle Cost (LCC)	**$ 67,071**	**$ 61,208**	**$ 67,745**	**$ 58,879**
Net Present Savings (NPS)	**N/A**	**$ 5,864**	**$ (674)**	**$8,192**
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% CO2e Reduction vs. Baseline	N/A	72%	25%	40%
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Energy Analysis:

	Site Energy Use (MMBtu/yr)			
End Use	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating***	**Heat Pump Space Heating***
Misc. (E)	9.1	9.1	9.1	9.1
Vent Fan (E)	2	2	2	2
Lg. Appl. (E)	6.5	8.06	6.5	6.5
Lights (E)	6.77	6.77	6.77	6.77
Cooling Fan/Pump (E)	0.39	0.08	0.39	0.08
Heating Fan/Pump (E)	0.53	0.15	0.53	0.15
Cooling (E)	0.98	0.73	0.98	0.73
Heating (E)	0	5.58	0	5.58
Heating (G)	17.78	0	17.78	0
Hot Water (E)	0.15	2.88	2.88	0.15
Hot Water, Suppl. (E)	0	0.56	0.56	0
Hot Water (G)	10.97	0	0	10.97
Lg. Appl. (G)	3.33	0	3.33	3.33
Total	58.5	35.9	50.82	45.36

	Site Energy Use (MMBtu/yr)			
Fuel	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating**	**Heat Pump Space Heating**
Electricity	26.4	35.9	29.7	31.1
Natural gas	32.1	0.0	21.1	14.3
Total	58.5	35.9	50.8	45.4

	Site Energy Use			
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Electricity (kWh)	7,743	10,524	8,707	9,103
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	Utility Costs (Electricity Rate = $0.0856/kWh & Gas Rate = $0.818/therm)			
Fuel	**Mixed-fuel Building**	**All-Electric Building**	**Heat Pump Water Heating**	**Heat Pump Space Heating**
Electricity (kWh)	$ 662.80	$ 900.87	$ 745.33	$ 779.20
Natural gas (therms)	$ 262.48	$	$ 172.72	$ 117.00

1.3 Revised definition of "Residential Building", Proposal 21-GP2-084, modifies WAC 51-11R-20218 and WAC 51-11R-40100

Brief Description: Move low-rise multifamily buildings (with dwelling units accessed from interior corridors) from the "residential building" category into the "commercial building" category and requiring them to comply with the Commercial Provisions of the WSEC.

Purpose of Change: This code change provides a uniform set of code requirements for all multifamily buildings, with the exception of buildings that have exterior walkway access to the individual dwelling units. There is no reason for three-story apartments and four-story apartments to be built under entirely different sets of code requirements. Inclusion of low-rise multifamily under the commercial energy code will result in nearly identical annual energy use but will allow jurisdictions with advanced local energy codes to bring them to the same standard that is applied to their medium-rise multifamily buildings. Note that low-rise hotel/motel buildings, a very similar building type, are already built in conformance with the commercial code provisions.

Review Process: The Technical Advisory Group reviewed this proposal, and it was revised several times after review by workgroups, including the proponent and key stakeholders. They felt this was a reasonable requirement, after reviewing the proponent's data on the comparing cost differences for the occupancy for both codes.

Probable benefits vs. probable costs: A comparison completed by the proponent looked at the cost for mandatory additional energy credits under both the Commercial Provisions and Residential Provisions showed a decrease in costs for the most cost effective provisions in each code, with the commercial options showing about a $5,700 savings over the residential options. In some areas the commercial code is more stringent, but those costs were nullified by the savings for the addition efficiency options.

There are advantages for code understanding, enforcement, and compliance in having a single set of requirements for all multifamily buildings, regardless of height.

Cost Comparison

Options Table, General: The commercial code C406 options for R-2 multifamily cost very little extra, while the residential code R406 options for R-2 multifamily have definite costs attached.

Options table costs for R-2 in the commercial energy code. The following credits are available for the 2021 code. It appears that the reduced pipe sizing credit alone will provide more than the 41 credits required under the new credit system, while *reducing* construction cost, and there are many other options.

- **#20: 42 credits Hot water distribution right-sizing using plumbing code Appendix M** (*reduces* construction cost due to smaller pipe sizes, insulation thickness, and circulation pump size)

(Other available options – those in **bold** below equal 41 credits, total $0.68/sf)

- #28: 19 credits Residential dishwasher & fridge with Energy Star "Most Efficient" label
- #07: 31 credits High performance DOAS
- **#14: 20 credits Renewable energy** ($0.37/sf @ $2.50/W)
- #21: 13 credits Hot water temp maintenance
- #25: 24 credits Reduced air leakage
- **#09: 4 credits 10% lighting power reduction** ($0.18/sf - PNNL)
- **#11: 6 credits: High-efficacy lamps** (no additional cost)
- **#12: 8 credits main lighting switch for whole unit** ($0.13/sf - PNNL)
- **#23: 3 credits low-flow shower heads** (no additional cost)
- #29: 6 credits Energy Star "most efficient" label washer & dryer
- **Total of items in bold: 41 credits, $0.68/sf = $558 for 820 sf.**

Options table costs for R-2 in the residential energy code. For residential, the TAG has recently approved the NEEA/Ecotope package of R406 changes (21-GP2-073). The required 6.5 credits could be provided for an R-2 multifamily building by any of several sets of options. One group is shown below with heat pump heating. These appear to be the least expensive packages available for multifamily, and the cost for either package will be considerably higher than the cost for meeting the commercial code options.

Residential code credit package, with DHP

- Credit 1.4: 1.0 credit for U-0.20 glazing ($887)
- Credit 2.2: 1.0 credit for 1.5 ACH HRV ($2034)
- Credit 3.4: 2.0 credits for Ductless Heat Pump ($3060)
- Credit 5.4: 2.5 credits for Tier III HPWH ($318)
- **Total: 6.5 credits, $6,299**

Other differences between commercial and residential codes; no cost increase

- Most opaque envelope R-values will be slightly *less* stringent, lower cost

Component	Residential	Commercial
Ceiling	**60**	49
Wood wall	**20+5 or 13+10**	20+3 or 13+7
Floor	30	**38**
Below-grade wall	**10 or 21+5 TB**	10 or 19
Slab on grade	**10 for 4 ft**	10 for 2 ft

- Fenestration U-values will be *more* stringent, cost difference covered in Credit Package

Component	Residential	Commercial
Windows	0.30	**U-0.26**
Skylights	U-0.50	**U-0.45**

- Air barrier leakage resistance requirement will be *more* stringent, cost difference covered in Credit Package

	Residential	Commercial
Test requirement	3 ACH 50	**0.25 (0.40) @75 Pa**

- Required ERV efficiency will be *slightly* more stringent, cost difference covered in Credit Package

	Residential	**Commercial**
Efficiency	1.0 cfm/W	**1.2 cfm/W**

1.4 Renewable Energy Required, Proposal 21-GP1-079, Adds a new section to WAC 51-11C-41100.

Brief Description: This proposal reduces the prescriptive window U-factor from 0.30 to 0.28.

Purpose of Change: Windows are an important component of the energy performance of any house. In many new homes windows represent just 6-8 percent of the envelope area but 45 to 49 percent of the total envelope heat loss. As one of the primary barriers between indoor and out, the openings of the building envelope; high performance windows, doors, and skylights are essential to an energy efficient building. As the ENERGY STAR® Program moves to lower U-Factors in v7.0, anticipated to be adopted for 2023, this proposal aligns the prescriptive requirements with the existing ENERGY STAR® v6.0 Program equivalent energy performance.

Review Process: The Technical Advisory Group discussed this proposal and concerns regarding availability of product. The proponent advised that the wait time was similar to other window products, and that Oregon currently requires a U-0.27 window and the 2024 IECC will also require a U-0.28 window, so the market is responding to the demand. This change would also remove one of the envelope options from the additional efficiency credits menu, but many other option still remain and one of the options in the proposed rule would reduce the overall number of credits required.

Probable benefits vs. probable costs: Homes with better envelope performance have an easier time maintaining a consistent mean radiant surface temperature, improving comfort for residents. Additionally, more advanced window systems typically provide reduced sound transmission, improving quality of life for home residents. Based on a 2,200 square foot prototype home with 15 percent glazing, the estimated incremental cost is $403 per dwelling, or $1.22 per square foot. The estimated annual energy savings is 389 kBtu, or 0.18 kBtu per square foot.

The analysis for cost effectiveness utilized four individual runs with the LCCA tool, for each comparing only the baseline to Alt 1, the same home with U-Factor 0.28 windows installed. The same size (2200 sq ft) was used and EIA average rates for natural gas and electricity were used ($0.95/Therm and $0.1007/kWh). The results showed positive Net Present Savings and NPS with Social Cost of Carbon for three of the four scenarios when a 30-year measure life is associated.

Simple payback was found to approximately 29.8 years in Seattle and 24.4 years in Spokane. Regardless of assumed measure life of windows, either 30 years (ENERGY STAR) or 40 years (Northwest Power and Conservation Council), this measure pays back within its lifetime. A 30-year measure life was used in the LCCA Tool. The Net Present Value and Net Present Value with Social Cost of Carbon were positive for Seattle homes with gas heating and both gas and heat pump heated homes in Spokane. The heat pump heated home in Seattle was close, but not positive. When the measure life in Seattle was switched to 40 years, the NPS with SCC would have both been positive as well.

Costs for window upgrades

Costs for moving to 0.28 from 0.30 U Factor windows was estimated using builder interviews and ENERGY STAR® v7.0 window specification analysis.

Source/U Factor	Target U 0.28
Builder interviews	$1.85/sq ft
ENERGY STAR	$1.57/sq ft
ICF IECC Cost Eff Analysis	$0.25/sq ft
Average	$1.22/sq ft
For Prototype Home	$402.60

Builder cost estimates (per sq ft):

- Builder A - $2.00
- Builder B - $1.10
- Builder C - $2.45
- Average - $1.85

Builder interviews consisted of two regional builders and one non-profit affordable housing builder. These three builders represent approximately 300 homes a year built in Washington State in both climate zones. Builders reported costs in late 2021, which were an increase of at least 30% when compared to early 2020.

ENERGY STAR cost estimates (per sq ft):

Assumed 15% glazing on 2,380 sq ft home (357 sq ft glazing):

- 0.27 windows Northern Climate = $1.19
- 0.28 windows Northern-Central Climate = $0.50
- 0.26 windows IECC Climate Zone 5 = $1.93
- Average = $1.21
- 130% inflation = $1.57

ICF-2021-IECC-Cost-effectiveness-Analysis report

Assumed 15% glazing on 2,380 sq ft home (357 sq ft glazing):

- 0.32 to 0.30 = $67/house or $0.19/sq ft
- 130% inflation = $87.1 or $0.25/sq ft

Savings for window upgrades

CZ	Heating system	Case	Modeled Heating and Cooling costs $/yr	Modeled Heating and Cooling savings $/yr	Modeled Heating and Cooling savings KBTU/yr	ENERGY STAR savings $/yr	Blended Savings $/yr
4C	Gas furnace	Base U 0.30	633				
		Proposed U 0.28	619	14			
	Heat Pump	Base	656		17,269		
		Proposed	643	13	16,918		
5B	Gas furnace	Base U 0.30	1003				
		Proposed U 0.28	987	16			
	Heat Pump	Base	1184		31,449		
		Proposed	1167	17	31,023		
All	All	Averaged and Total		$15	388.5	$18	$16.50

These estimates come from assumption of a 2,200 sq ft prototype home on a vented, enclosed crawl space with 3 bedrooms. 15% glazing of window to CFA assumed.

Homes were modeled with 2021 WSEC-R Integrated Draft Prescriptive elements, and federal minimum standard equipment (HP homes followed 2018 WSEC-R requirement to have a single DHP providing 60% of the heating load) only to see impact on base case of home. Heating and Cooling savings were calculated in REM/Rate v16.0.6

Energy Costs used 2021 EIA average rates

ENERGY STAR savings were lowest average savings estimates available in the "ENERGY STAR® Windows, Doors, and Skylights Version 7.0 Criteria Analysis Report" – July 2021

Cost Effectiveness

CZ\Metric	Net Cost	Measure Savings	NPS w/o SCC	NPS w/ SCC	Simple Payback
Seattle HP	$402.60	129 kWh	(78)	(42)	31
Seattle HP 40-year measure	$402.60	129 kWh	62	99	31
Seattle Gas	$402.60	14.7 Therms	148	204	28.8
Spokane HP	$402.60	169 kWh	92	140	25.2
Spokane Gas	$402.60	16.8 Therms	259	328	23.7

1.5 Section R406 revisions, Proposal 21-GP2-073, This proposal encompasses three major changes: changes to the fuel normalization table in WAC 51-11R-40610, changes to the number of credits required in WAC 51-11R-40620, and adjustment to the energy credits themselves in WAC 51-11R-40621.

Brief Description: There are two options going forward for this proposal, so each of those three WACs has an Option 1 and Option 2. Option 1 is the proposal as reviewed and recommended by the technical advisory group and Option 2 is a revised proposal that takes into account the other code change proposals submitted and how they affect Section R406 and the energy reduction target for the code cycle.

Fuel normalization table: Both options revise the table to include more detailed descriptions of heating systems and supplemental heating systems. Option 1 uses a gas baseline system from the 2018 code for assigning credits while Option 2 uses the new proposed 2021 code baseline of a heat pump system.

Additional energy efficiency credit requirements: Option 1 is the proposal based on the number of credits required to meet the energy reduction target for the code cycle. Option 2 is a revised proposal that takes into consideration the gains towards the reduction target made by the other proposals in the proposed rule.

Energy credit table: Option 1 shows credit adjustments based on the system type from the fuel normalization table, and eliminates options based on less stringent code requirements and federal minimums. Option 2 is revised proposal that takes into account the other code changes in the proposed rule and adjusts credits or requirements to maintain the 600 kWh per half credit standard.

Purpose of Change: This proposal is designed to meet the high-level goal of RCW 19.27A.160. changes to Section R406 are expected to lead a 10 percent energy reduction over a 2006 WSEC compliant home. These savings are primarily attributed to the credits required to comply with code in Section R406.3, along with prescriptive envelope upgrades. The amended proposal in Option 2 is intended to reflect the heat pump water and space heating proposals in the proposed rule, along with correlating changes to the envelope requirements.

Review Process: The Technical Advisory Group (TAG) discussed the Option 1 portion of this proposal only; Option 2 was offered as a modification during the review process by the Mechanical, Ventilation and Energy Codes Committee. This was a contentious proposal that passed on a 10 to 8 vote by the TAG. A large portion of the discussion time was spent on the number of required credits, which was modified fairly significantly in Option 2. Concerns were voiced that the pricing of the equipment was too low. There was also debate on the need for the fuel normalization table. In the end, the majority of the TAG members felt that the proposal was well documented and as accurate as a snapshot in time allows.

Probable benefits vs. probable costs: Costs will vary depending on the options selected. There was no comparison of the difference in cost between the 2018 and 2021 requirements, but only a measure by measure estimate of cost based on 6 prototype buildings. Those costs ranged from $173 to $5,245 per dwelling. Energy savings for various prototype buildings and systems range from 4 kWh to 1941 kWh annually. The benefits of the measure include a more extensive and easier to understand fuel normalization table and updated information based on model code and federally mandated requirements. The proposal also is intended to meet the high-level goal of RCW 19.27A.160, and is expected to lead to a 10 percent energy reduction over the 2018 code.

First cost and energy savings estimates have been developed using an estimating procedure used by the Northwest Power and Conservation Council (NPCC). This method uses 6 prototype single family homes and one multi-family building to assess regional energy impacts. This includes: a 1344 sf rambler (crawl space and slab), a 2200 square foot rambler (crawl space and slab), a 2866 sf home with half basement,

a 5000 sf home with a full basement, and a multifamily dwelling units (modeled a 2 story, exterior entry, low-rise building and a 3-story double loaded corridor). For each building, both cost and energy savings are estimated for each prototype and each measure.

First Cost: First cost and energy savings estimates have been developed using an estimating procedure used by the Northwest Power and Conservation Council (NPCC) and ran through the Office of Financial Management Life Cycle Cost Tool. The first costs were developed using multiple sources of information:

- NPCC, the Regional Technical Forum (RTF), http://rtf.nwcouncil.org/ This is a federally mandated multi-state compact that develops the efficiency resources for the region's electric utilities
- Navigant is a business consulting firm which provides resource planning for both gas and electric utilities, including gas utilities in Washington State. http://www.navigant.com/industries/energy/
- CEE is the Consortium for Energy Efficiency. CEE is the US and Canadian consortium of gas and electric efficiency program administrators. http://www.cee1.org/
- This study also uses cost information provided to the SBCC by Ecotope.
- PassiveHouse consultant aided with pricing the higher insulation and envelope detailing.
- Inflation has been accounted for on any cost estimates sourced from previous years.

All costs shown are incremental costs for each measure, the base cost is related to the prescriptive requirement of the code and the incremental costs are associated with the option requirement of Table R406.2. Keeping this in mind, the incremental cost for a ductless mini-split, in single family, is the added equipment cost associated with purchasing a higher efficiency heat pump (since DHPs are required in the prescriptive code in electric zonal single-family homes); while in multifamily, the incremental cost of a heat pump is higher because it is compared to electric baseboards. Water heating systems in multifamily are assumed to serve more than one unit, therefore their incremental costs are lower than for single family. The cost analyses provided in this report use a weighted average cost method to represent the wide range of new homes constructed in Washington. Each of the predominant dwellings, as defined in Section R406.2, are shown in the LCCA case studies (large dwelling units represent a minor fraction of the overall building stock, therefore were omitted from the analysis). For each single-family dwelling unit size, the predominant heating system types are shown individually ("Gas Home", "Heat Pump Home" and "Electric Zonal Home") in order to show cost effectiveness for all available heating system types. The cost model is built using the five prototype designs, including a 1344 sf rambler (both on a slab and over a crawlspace), 2200 sf rambler (both on a slab and over a crawlspace), 2688 with half basement. The costs associated with the crawl space and slab prototypes were normalized into each of the dwelling unit sizes per Section R406.2. Multifamily costs were based on an electric zonal heating system. A first cost estimate is developed for each option and for each prototype. Then, the incremental 4 cost of each prototype is weighted by the expected construction volumes to provide an overall average measure cost. The tables, Incremental Cost of Single Family Options and Incremental Cost of MF Options, provides both prototype and weighted measure cost. Unlike the energy savings estimates, the first cost numbers are a fixed value for each energy measure and do not change based on the selected package of measures modeled for the LCCA. This assumes that incremental costs of each option do not have the any interdependency – contrary to the associated

energy savings, as stated earlier. This will no longer be the case as buildings become more efficient. Higher levels of envelope insulation and tighter construction leads to smaller HVAC systems, and therefore a cost credit should be applied. But as mentioned, this approach was not applied in this analysis.

Energy Savings Estimates: Energy savings estimates used in the life cycle cost analysis were developed using SEEM. The SEEM energy simulation program was used to develop the energy savings targets and estimates for the 2009- 2018 iterations of the residential portion of Washington State Energy Code. SEEM is used by the Northwest Power and Conservation Council RTF to estimate savings for most of the regional utility conservation programs. The modeling protocol is intended to represent the wide variety of new homes constructed in Washington, to summarize the average savings that can be attributed to each option listed in Table R406.3 and estimate the overall consumption of the residential sector for each code cycle. The SEEM program is designed to model small scale residential building energy use. The program consists of an hourly thermal simulation and an hourly moisture (humidity) simulation that interacts with duct specifications, equipment, and weather parameters to calculate the annual heating and cooling energy requirements of the home. It is based on algorithms consistent with current American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), American Heating and Refrigeration Institute (AHRI), and International Organization for Standards (ISO) calculation standards. In order for the SEEM model to be used in efficiency measure assessments, it must be calibrated to baseline and efficient-case consumption. Calibration for single family, multi-family, and manufactured homes are separate endeavors that utilize metered data from a sample of homes in the NW to estimate energy consumption. SEEM was recalibrated in response to findings from the 2011 Residential Building Stock Assessment. This provides calibrated results for Pacific NW homes. For single family construction, the energy model is built using six RTF-approved prototype designs, including: a 1344 sf rambler (both on a slab and over a crawlspace), 2200 sf rambler (both on a slab and over a crawlspace), 2688 with half basement and 5000 sf full basement home. These six prototypes are then modeled with the three primary heating system types (“gas home”, “Heat Pump Home” and “Electric Resistance Home”) and then simulated in the two major climate zones in the state. Each energy conservation measure (option in Table R406.3) is then modeled independently in each of these scenarios, with the energy savings weighted down to a representative credit value shown in Table R406.3. For low-rise multifamily construction, the same method was used as for single family 3. The presumed predominant construction-types are a 2-story, garden style (exterior entry) building and a 3-story 3 ‘double loaded corridor’ building. The annual energy use, utility savings, and incremental cost were then normalized to a per unit basis. After individual measures were modeled independently and associated savings determined, each prototype summarized in this LCCA analysis was modeled with a selection (package) of R406 options required to be code compliant (both in 2018 and 2021). This important step not only illustrated the code-to-code savings, but it also accounts for interaction between different credit options within the table. As more measures are utilized in a home, more interaction occurs between measures, and the individual savings attributed to that measure are not realized when paired with a host of other options. For instance, higher envelope insulation will de-rate the savings available from increased equipment efficiencies. It is important to capture this interaction through the modeling exercise or else the anticipated savings estimates will be overinflated. It is the annual energy savings obtained from these packages of measures that are used in determining the life cycle cost of the code change proposal.

Energy and Cost Summary Tables:

Table 1: Incremental Cost of Single Family options, by home size

Incremental Cost of Single Family Options

				Prototypes Weight % by Floor Area			
				1344	2200	2688	5000
Option-Description	Gas Credit Value	HP Credit Value	Weighted Measure Cost	15%	72%	11%	2%
1.1 - U-.24 Glaze	0.5	0.5	$ 1,730	$ 991	$ 1,790	$ 1,987	$ 3,688
1.2 - U-.20 Glaze	1	1	$ 2,537	$ 1,454	$ 2,625	$ 2,914	$ 5,409
1.3 - 5% UA reduc	0.5	0.5	$ 1,261	$ 955	$ 1,270	$ 1,762	$ 476
1.4 - 15% UA reduc	1	1	$ 3,263	$ 1,925	$ 3,255	$ 4,676	$ 5,802
1.5 - 22.5% UA reduc	2	1.5	$ 4,721	$ 2,938	$ 4,850	$ 5,735	$ 7,852
1.6 - 30% UA reduc	3	2.5	$ 11,235	$ 6,819	$ 12,095	$ 10,587	$ 16,991
2.1 - 2 ACH, HRV	1	0.5	$ 2,264	$ 1,395	$ 2,284	$ 2,790	$ 5,190
2.2 - 1.5 ACH, HRV	1.5	1	$ 5,411	$ 3,334	$ 5,457	$ 6,667	$ 12,402
2.3 - 0.6 ACH, HRV	2	1.5	$ 6,988	$ 4,306	$ 7,048	$ 8,612	$ 16,019
3.1a - Furnace	1	1	$ 252	$ 252	$ 252	$ 252	$ 252
3.2a - 9.5 HSPF HP	0.5	0.5	$ 1,388	$ 1,388	$ 1,388	$ 1,388	$ 1,388
3.3a - GSHP	1.5	1.5	$ 11,034	$ 10,900	$ 10,900	$ 10,900	$ 17,600
3.4 - DHP	1.5	1.5	$ 1,530	$ 1,530	$ 1,530	$ 1,530	$ 1,530
3.5a - 11.0 HSPF HP	1	1	$ 1,530	$ 1,530	$ 1,530	$ 1,530	$ 1,530
3.6a - DHP (15% elec)	2	2	$ 5,901	$ 5,901	$ 5,901	$ 5,901	$ 5,901
4.1 - Deeply buried	1	0.5	$ -	$ -	$ -	$ -	$ -
4.2 - HVAC inside	1.5	1	$ 328	$ 328	$ 328	$ 328	$ 328
5.1 - DWR	0.5	0.5	$ 437	$ 437	$ 437	$ 437	$ 437
5.2 - 0.80 gas DHW	0.5	0.5	$ 640	$ 640	$ 640	$ 640	$ 640
5.3 - 0.91 gas DHW, GSHP	1	1	$ 1,009	$ 1,009	$ 1,009	$ 1,009	$ 1,009
5.4 - Tier III HPWH	2	2	$ 955	$ 955	$ 955	$ 955	$ 955
5.5 - CO2 HPWH	2.5	2.5	$ 3,824	$ 3,824	$ 3,824	$ 3,824	$ 3,824
6.1 - Solar pV	1	1	$ 5,040	$ 5,040	$ 5,040	$ 5,040	$ 5,040
7.1 - ES Appl+ventless Dryer	0.5	0.5	$ 505	$ 505	$ 505	$ 505	$ 505

Table 2: Modeled Energy Savings - Single Family, by home size and heating system type

	S				M				MF
	gfac	gfac	ashp	zonl	gfac	gfac	ashp	zonl	zonl
Options Table 2021	kWh	Therm	kWh	kWh	kWh	Therm	kWh	kWh	kWh
mandatory req's	0	0	0	0	0	0	0	0	0
windows U=0.24	114	5	1143	173	292	5	302	348	132
windows U=0.2	160	12	1192	291	369	18	492	597	263
envelope 3 - 5% UA	18	0	1101	94	-70	-2	59	122	-34
envelope 4 - 15% UA	151	24	1243	406	288	28	528	648	223
envelope 5 - 22.5% UA	303	33	1315	581	577	41	817	1015	420
envelope 6 - 30%UA	348	55	1430	821	887	69	1158	1456	555
air leakage 1 hrv	-116	3	1059	-10	-271	19	105	111	329
air leakage 2 hrv	4	45	283	344	87	67	504	664	642
air leakage 3 hrv	91	54	414	487	530	78	762	997	934
AFUE .95	-84	34	-	-	55	51	-	-	
HSPF 9.5	-	-	248	-	-	-	328	-	
DHP HSPF 10(zonal only)	-	-	-	689	-	-	-	1129	-41
HSPF 11	-	-	371	-	-	-	980	-	
DHP HSPF 10 whole house (zonal only)	-	-	-	1154	-	-	-	2185	740
ducts inside	356	32	385	-	781	38	666	-	
drain water heat recovery	76	23	260	247	-55	33	282	318	182
dwh gas UEF 0.80	18	27	-	-	3	34	-	-	
dwh gas UEF 0.91	-28	39	-	-	12	48	-	-	
hpwh Tier III	-930	121	1407	1395	-1167	153	1761	1790	973
UEF 2.9	-813	121	1536	1512	-1099	156	1916	1941	1055
Energy Star appliances	722		824	784	625		750	776	629

Table 3: Incremental Cost of Multifamily options and Modeled Energy Savings (Zonal Electric only)

Option-Description	Credit Value		Measure Cost
1.1 - U-.24 Glaze	0.5		---
1.2 - U-.20 Glaze	1		$ 887
1.3 - 5% UA reduc	---		$ 173
1.4 - 15% UA reduc	1		$ 947
1.5 - 22.5% UA reduc	1.5		$ 1,383
1.6 - 30% UA reduc	2		$ 3,779
2.1 - 2 ACH, HRV	0.5		$ 851
2.2 - 1.5 ACH, HRV	1		$ 2,034
2.3 - 0.6 ACH, HRV	1.5		$ 2,627
3.1a - Furnace	1		$ 252
3.2a - 9.5 HSPF HP	---		---
3.3a - GSHP	1		---
3.4 - DHP	2		$ 3,060
3.5a - 11.0 HSPF HP	---		$ -
3.6a - DHP (15% elec)	3		$ 5,245
4.1 - Deeply buried	0.5		$ -
4.2 - HVAC inside	---		---
5.1 - DWR	---		$ 505
5.2 - 0.80 gas DHW	0.5		---
5.3 - 0.91 gas DHW, GSHP	1		---
5.4 - Tier III HPWH	2.5		$ 318
5.5 - CO2 HPWH	3		$ 1,275
6.1 - Solar pV	1		$ 5,040
7.1 - ES Appl+ventless Dryer	1.5		$ 505

Life Cycle Cost Analysis: The State Building Code Council has adopted the use of Washington State Department of Financial Managements (OFM) life cycle cost tool for this analysis. The OFM life cycle cost tool used to provide these results is based on the methodology of National Institute of Standards, HANDBOOK 135 Life-Cycle Costing Manual. The OFM model is designed for state projects and commercial construction. This model was modified to support residential construction. This primarily required changing the fuel escalation rates from commercial to a residential standard. For the full life cycle cost analysis, see https://sbcc.wa.gov/sites/default/files/2022-05/073_2021-R406-LCCA_Narrative_with%20Results.20220408.pdf or page 15 of https://sbcc.wa.gov/sites/default/files/2022-09/073_TM_R406_CBA.pdf, which is also linked in the table of **Code Change Proposals Marked as Significant Impact.**

1.6 Maximum air leakage rate, Proposal 21-GP2-089: Modifies WAC 51-11R-40240

Brief Description: The maximum leakage rate is reduced from 5 air changes per hour to 3 air changes per hour for single family and 0.25 cfm (the same as the commercial requirement) for multifamily. The proposal also removes the volumetric adjustment originally intended to provide an advantage to smaller dwelling units with lower ceiling heights.

Purpose of code change: This change aligns the Washington State Building code with the International Energy Conservation Code requirement for air leakage and reduces energy loss through improving building air leakage performance.

Review Process: The TAG reviewed this proposal and the majority felt that it would be beneficial to adopt the model code requirements for air leakage. The main concern of those opposing the change is the loss of one of the credit options in R406, and it was felt that other options being added would make up for that loss.

Probable benefits vs. probable costs: The proponent submitted, and the TAG agreed, that there was no cost associated with this code change proposal. The testing remains as required by the previous code edition.

1.7 Water heater installation location, Proposal 21-GP2-080: Modifies WAC 51-11R-40240

Brief Description: This proposal requires that water heaters be located within conditioned space except for highly efficient water heaters where the standby losses are overcome by the efficiency of the unit performance.

Purpose of code change: Standby losses on electric resistance tanks continue to be a source of wasted energy and occur year-round regardless of location. By requiring water heating tanks that rely on electric resistance heating to be located inside conditioned spaces, similar to locating heating ducts inside, the standby losses are minimized as they are absorbed into the conditioned space. While tank manufacturers have increased tank insulation levels in the past several years, water heaters still lose heat to the space throughout the year and provide an unnecessary source of wasted energy. Exceptions are given for 1) efficient water heaters that can operate in unconditioned spaces where the net benefit of standby losses is overcome by the efficiency of the unit performance, or 2) smaller tanks where standby losses are extremely minor

Review Process: The Technical Advisory Group reviewed this proposal and made several changes to clarify the intent and make enforcement easier. Discussions on this proposal included the loss of useable living space and how this would affect heat pump water heaters and combustion air for gas water heaters.

Probable benefits vs. probable costs: The primary benefit to the homeowner is reduced energy bills due to any standby losses being inside the conditioned space. There are no cost increased expected as part of this base proposal - builders and consumers still have a choice of water heater products and fuels to utilize, provided they are placed in the correct locations. If an exception needs to be taken, upgrading from an electric resistance water heater to a water heater with a UEF of 2.0 would

incur a cost and that is reflected below as the least cost option, other than installing a smaller water heater (<40 gallons) which would result in a negative incremental cost.

Estimated cost of about $746 per dwelling unit or $0.33 per square foot.
Energy Savings: Estimated annual energy savings of 271 kWh per dwelling unit

This proposal has the added benefit of saving carbon emissions if the builder chose to install a tank with a higher UEF when in an unconditioned space in lieu of locating the electric resistance tank inside. Similarly, if a gas water heater were chosen to satisfy this code requirement, the carbon emissions are also less than installing an electric resistance tank (using US average grid emission intensity of 0.92 lbs CO2 per kWh and EIA estimates of 117 lbs CO2 per MMBtu).

Description	Value	Unit
US Grid Avg. Emission Intensity	0.91	lbs CO2 per kWh
Reference Load	50	gallons hot water
Density of Water	8.34	lbs/gallon
City Water Temp	55	°F
Hot Water Temp	120	°F
Hot Water Load	27,105	Btu
Gas Water Heater		
UEF	0.62	
CO2 Combustion	117	lbs Co2 per MMBtu
Emissions per 50 gallons	**5.1**	**lbs CO2**
Electric Resistance Water Heater		
UEF	0.92	
Electricity Consumption	9	kWh
Emissions per 50 gallons	**7.9**	**lbs CO2**
UEF 2.0 Water Heater		
UEF	2.0	
Electricity Consumption	4	kWh
Emissions per 50 gallons	**3.6**	**lbs CO2**

Carbon emissions factors:
Electricity - EIA: https://www.eia.gov/tools/faqs/faq.php?id=74&t=11
Natural Gas - EIA: https://www.eia.gov/environment/emissions/co2_vol_mass.php (based on Carbon factors provided by the U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks, Tables A-32, A-38, and A-232

1.8 Air handler location, Proposal 21-GP2-032: Modifies WAC 51-11R-40320

Brief Description: This change requires the air handler to be located within the conditioned space

Purpose of change: Locating air handlers in the conditioned space will reduce labor and materials costs by "right sizing" the ducts. Reduced linear footage of ductwork and smaller-diameter duct sizes are required if the HVAC contractor uses Air Conditioner Contractors of America (ACCA) manual D to size the thermal distribution system when they calculate ACCA manual J and S design loads for heating and cooling system sizing per WSEC-R. There is a one-time design change if the builder is currently locating the air handler in an unconditioned space such as a garage or vented attic. There are also design communication needs between the designer/builder and HVAC contractor. Verifying QA, and WSEC-R and IRC/IMC-WA, compliance is simpler because the AHJ and other third-party inspectors may have better access to the air handlers located in the conditioned space for inspection and installation. There is additional thermal comfort because the air handler does not have to reheat or re-cool between HVAC cycles, thereby reducing cold cycle blow and potential behavioral energy saving when occupants do not change the thermostat settings.

Review Process: The TAG debated the pros and cons of this proposal. The stated cons were the noise from the air handlers and finding/creating room in the design for the air handler. The pros were the energy savings of having the leakiest portion of the ducts and cabinet leakage itself within the conditioned space and not losing that heat to the unconditioned space. It also make it easier to meet the duct leakage requirements of the code and for the homeowners to change the air filters.

Probable benefits vs. probable costs: The life cycle of the unit is typically increased due to ideal installation practices. Energy savings from locating the air handler in the conditioned space is currently worth 0.5 energy credit (600 kWh/year), roughly as assumed in 2018 energy credits 4.1 and 4.2 Thermal Distribution System. Leakage from the air handler and thermal conduction losses waste more energy when not located in the conditioned space. This is because the HVAC system box has the greatest pressures and temperatures when compared to leakage of a floor, wall, or ceiling supply or return register. The estimates of the SEEM model used to determine 4.1 energy credits are, therefore, conservative.

600 kWh/year x $0.10/kWh = $30-$60 per year over the life of the 1,500 sf prototype home. At a design cost of $100, the simple payback is 2 to 4 years

II. List of Code Proposals

Washington State Code Change Proposals

Log Number	Proposed Section and Title	Type of Change	Description
21-GP2-011	**R402.1.4** R-value computation	Code Change (editorial) (21-GP2-011)	The code change removes a redundant sentence from the middle of the IECC language.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-012	**Table R402.4.1.1** Air barrier, air sealing and insulation installation	Code Change (editorial) (21-GP2-012)	This code change revises the new IECC footnote b for clarity.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-013	**R403.5.1.1 Demand recirculation water systems serving an individual dwelling unit**	Code Change / Editorial (21-GP2-013)	Removes "Where installed," at the beginning of the revised IECC section. (Note: no change is shown in R403.5.4 as ICC added this language for the 2021 code, but it was removed via 014, so there is no actual change.)
21-GP2-014	**R403.5.4 Drain water heat recovery**	Code Change / Editorial (21-GP2-014)	
21-GP2-015	**R403.12 Residential pools and permanent residential spas**	Code Change / Editorial (21-GP2-015)	
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-022	**R401.2** Compliance	Code Change (21-GP2-022)	This change corrects an error in the previous code that stated that compliance via Section R405 also required compliance with Section R406. R405 carries its own additional credit weighting and thus is not intended to also comply with Section R406.
	Table R405.2(1) Mandatory compliance measures for total building performance	Code Change (21-GP2-022)	An error is also corrected by removing reference to R406. The additional efficiency is covered by the energy reduction targets in items 2 through 5 of Section R405.2
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		

Log Number	Proposed Section and Title	Type of Change	Description
21-GP2-023	**Table R406.3** Energy credits	Code Change (21-GP2-023)	Option 3.2 requires a cold climate heat pump to be used in areas with a winter design temperature at 23° or below.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code; Addresses a specific state policy or statute (energy conservation)		
21-GP2-024	**Table R406.3** Energy credits	Code Change (21-GP2-024)	Option 3.5 allows an alternate cold climate 10 HSPF heat pump to be substituted for an 11 HSPF heat pump but will require a cold climate heat pump similar to Option 3.2 in 023, above.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code; Addresses a specific state policy or statute (energy conservation)		
21-GP2-025	**Table R406.3** Energy credits	Code Change (21-GP2-025)	Option 3.6 also allows a substitution of a 9 HSPF heat pump for the required 10 HSPF in some cases.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code; Addresses a specific state policy or statute (energy conservation)		
21-GP2-032	**R403.3.4.1 Sealed air handler**	Code Change (21-GP2-032)	This change requires the air handler to be located within the conditioned space.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code; Addresses a unique character of the state		
21-GP2-034	**Table R406.3 Energy credits**	Code Change (21-GP2-0234)	New Option 3.8 allows a half credit for a connected thermostat.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation)		

LOG NUMBER	PROPOSED SECTION AND TITLE	TYPE OF CHANGE	DESCRIPTION
21-GP2-035	**R406.3** Additional energy efficiency requirements	Code Change (21-GP2-035)	Both options include a new 150 square foot threshold for additions to trigger this requirement.
	R502.1 General (Additions)	Code Change / Editorial (21-GP2-035)	The phrase "except as specified in this chapter" was added to support the new section R502.3.1.1.
	R502.1.1 Small additions	Code Change (21-GP2-035)	A new section was added to exempt small additions (less than 150 ft^2) from the requirement to obtain additional energy efficiency credits in Section R406.
	R502.3.1.1 Existing ceilings with attic spaces	Code Change (21-GP2-035)	This new section requires that when additions over 150 square feet adjoin existing attic spaces, the existing attic space needs to be brought into full compliance with the envelope provisions in R402.
	R502.3.2 Heating and cooling systems	Code Change (21-GP2-035)	The section is reworded for clarity, and exception 1 is correlated with the change in R502.1.1. Former exception 3 is deleted to correlate with the IECC change to require all ducts to be tested.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation); Addresses a unique character of the state		
21-GP2-046	**R403.5.2 Water volume determination (new)**	Code Change (21-GP2-046)	This section just provides the reference and procedure for determining the volume of water in piping when selecting one of the new options for credits in Section R406. This is not a base code requirement.
	Table R406.3 Energy credits	Code Change (21-GP2-046)	New Option 5.2 provides half a credit for compact hot water distribution systems as is required in the commercial energy code provisions and as detailed in Section R403.5.2.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		

Log Number	Proposed Section and Title	Type of Change	Description
21-GP2-047	**Table R406.3** Energy credits	Code Change (21-GP2-047)	New Option 5.2 provides half a credit for compact hot water distribution systems as is required in the commercial energy code provisions and as detailed in Section R403.5.2.
	R403.5.2 Water volume determination (new)	Code Change (21-GP2-047)	This section just provides the reference and procedure for determining the volume of water in piping when selecting one of the new options for credits in Section R406. This is not a base code requirement.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-049	**R403.4.1 Protection of piping insulation**	Code Change (editorial) (21-GP2-049)	Clarification of the intent or equipment maintenance, along with a requirement that the insulation be removable near the equipment requiring maintenance.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-050	**Table R406.3** Energy credits	Code Change (21-GP2-050)	New Option 3.7 provides credit for an air to water heat pump with a COP rating of 3.2.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation)		
21-GP2-065	**R403.13** Heat pump space heating	Code Change (21-GP2-065)	This new section requires that space heating be provided by a heat pump—either gas or electric—as a method to reduce greenhouse gas emissions and save energy. There are exceptions provided for dwellings with small heating loads and allowances for supplementary heating following the requirements of Section R403.1.2.
	Table R405.4.2(1) Specifications for the standard reference and proposed designs	Code Change (21-GP2-065)	Heating system is revised to align with the baseline of heat pump heating introduced in this code through 21-GP2-065.
	R503.1.2 Heating and cooling systems	Code Change (21-GP2-065)	An exception was added to this section to state that replacement heating equipment is not required to comply with the heat pump requirement as long as it does not exceed the heating capacity of the equipment being replaced.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation/carbon emissions reduction)		

Log Number	Proposed Section and Title	Type of Change	Description
21-GP2-066	**R403.5.7** Heat pump water heating	Code Change (21-GP2-066)	This new section requires that service water heaters in single family dwellings, duplexes and townhouses be provided by heat pump water heaters. Exceptions are provided for small water heaters, small dwelling units, supplemental water heating systems, and some renewable energy systems. This includes allowances for both gas and electric heat pump water heaters.
	R403.5.7.1 Supplementary heat for heat pump water heating systems	Code Change (21-GP2-066)	This is a support section for R403.5.7 and sets requirements for when a supplemental water heating system can be used with the heat pump water heater.
	Table R405.4.2(1) Specifications for the standard reference and proposed designs	Code Change (21-GP2-066)	Service water heating was revised to align with the baseline of heat pump water heating as introduced in this code through 21-GP2-066.
	R503.1.3 Service hot water systems	Code Change (21-GP2-066)	An exception was added to this section to state that replacement water heating equipment is not required to comply with the heat pump requirement as long as it does not exceed the heating capacity of the equipment being replaced.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation/carbon emissions reduction)		
21-GP2-070	**Table R405.2(2)** Carbon emissions factors	Code Change (21-GP2-070)	This table is moved from R405.3 to R405.2(2) and the metric for electricity is changes from 0.80 to 0.44 to better align with the commercial energy code, the Clean Buildings law and the OFM lifecycle cost tool.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation)		

LOG NUMBER	PROPOSED SECTION AND TITLE	TYPE OF CHANGE	DESCRIPTION
21-GP2-073 Option 1 Option 2	**R406.2** Carbon emission equalization	Code Change (21-GP2-073)	The last sentence was removed. It was deemed redundant.
	Table R406.2 Fuel normalization credits	Code Change (21-GP2-073)	There are two options being presented for this table. Both options revise the table to include more detailed descriptions of heating systems and supplemental systems. **Option 1** is the initial technical advisory group recommendation based on the original proposal and the goal of achieving the required energy savings for the cycle. **Option 2** is a revised proposal that takes into account the other code change proposals going forward to public hearing and the changes in equipment values based on the new requirements in the proposed rule.
	R406.3 Additional energy efficiency requirements	Code Change (21-GP2-073)	Again, there are two options being presented for this table. Both tables include a new 150 square foot threshold for additions to trigger this requirement. **Option 1** is the initial technical advisory group recommendation based on the original proposal and the goal of achieving the required energy savings for the cycle. **Option 2** is a revised proposal that takes into account the other code change proposals going forward to public hearing and the reduction in energy use based on the new requirements in the proposed rule.
	Table R406.3 Energy credits	Code Change (21-GP2-073)	This section also has two options. For both options, one half point is equivalent to a 600 kWh energy savings. Some options were eliminated due to the fact they are now a part of the base code requirements. **Option 1** is the initial technical advisory group recommendation based on the original proposal. The credits are based on the heating system type from Table R406.2. **Option 2** is a revised proposal that takes into account the other code change proposals going forward to public hearing. Based on the heat pump space and water heating changes, there is no differentiating between the systems types for point values. Instead, there

LOG NUMBER	PROPOSED SECTION AND TITLE	TYPE OF CHANGE	DESCRIPTION
			are options that are just not available with some systems types, as identified by footnote d. Some options are no longer available based on the fact that the base requirements now incorporate the provisions contained therein; some are just adjusted to yield a similar energy savings over the base code, or the point value is changed based on the savings reflected.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation/carbon emissions reduction)		
21-GP2-079	**Table R402.1.2** / **R402.1.3** Insulation and fenestration requirements by component	Code Change (21-GP2-079)	This proposal changes the fenestration U-factor from 0.30 to 0.28 in both tables.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation)		
21-GP2-080	**R403.5.5** Water heater installation location	Code Change (21-GP2-080)	This section requires that water heaters be located within conditioned space except for highly efficient water heaters where the standby losses are overcome by the efficiency of the unit performance.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (energy conservation)		
21-GP2-081	**R402.4.2** Fireplaces	Code Change / Editorial (21-GP2-081)	This section was moved to **R402.3.6**.
	R402.4.2.1 Gas fireplace efficiency	Code Change / Editorial (21-GP2-081)	This section was moved to Section **R403.7.2.**
	R402.4.4 Combustion air openings	Code Change / Editorial (21-GP2-081)	This section was moved to **R402.3.5.**
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-082	**R402.4.1** Building thermal envelope air leakage	Code Change (21-GP2-082)	"Air leakage" is added to the title for clarity. An additional subsection is added so the section references are updated.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		

LOG NUMBER	PROPOSED SECTION AND TITLE	TYPE OF CHANGE	DESCRIPTION
21-GP2-084	R202 Definition "**Residential building**"	Code Change (21-GP2-084)	This definition change alters the scope of the Washington State Energy Code, Residential Provisions to resemble more closely that of the International Residential Code. Multifamily buildings with dwellings directly accessed from the outdoors will remain in the residential provisions, but other R-2 buildings are moved under the commercial provisions.
	R401.1 Scope	Code Change (21-GP2-084)	The scope of the Washington State Energy Code, Residential Provisions was changed to resemble more closely the scope of the International Residential Code. Multifamily buildings with dwellings directly accessed from the outdoors will remain in the residential provisions, but other R-2 buildings are moved under the commercial provisions.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (RCW19.27A.160, energy conservation)		
21-GP2-088 **21-GP2-082**	**R402.4.1.2** Testing	Code Change (21-GP2-082. 21-GP2-088)	The specifics on the testing standard were moved from the exception into the main body of the section and the test must include information on the time, date and location where performed. Requirements were also added that the testing personnel be trained by an accredited program. The second exception from the second set of exceptions was moved to Section R402.4.1.3. The volume adjustment capping the ceiling height at 8.5 feet was removed.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: The amendment clarifies the intent or application of the code		
21-GP2-082 21-GP2-089	**R402.4.1.3** Leakage rate	Code Change (21-GP2-082, 21-GP2-089)	A new set of subsections was added to separate out the requirements for single family and multifamily dwelling air leakage testing. The maximum leakage rate was reduced to 3 air changes per hour for single family and 0.25 cfm (the same as the commercial requirement) for multifamily.
	Statutory Criteria (from RCW 19.27A/RCW 19.27.020) for amendment: Addresses a specific state policy or statute (RCW19.27A.160, energy conservation)		

(1)(b) Determine that the rule is needed to achieve the general goals and specific objectives stated under (a) of this subsection, and analyze alternatives to rule making and the consequences of not adopting the rule:

The Council is required to adopt and maintain the state building code, as provided in chapters 19.27, 19.27A, and 70.92 RCW, and the state legislature. The primary objective of the Council is to encourage consistency in the building code throughout the state of Washington and to maintain the building code consistent with the state's interest as provided in RCW 19.27.020. The statewide code adoption process is defined in WAC 51-04 and the Council bylaws. All proposals are submitted in writing on the appropriate form with the indicated supporting documentation. Each proponent must identify where a proposed amendment has an economic impact and estimate the costs and savings of the proposal on construction practices, users and/or the public, the enforcement community, and operation and maintenance. There are no alternatives to this procedure. If the rule is not adopted, this will be a violation of the State Law, which will affect the promotion of energy efficiency and safety in buildings consistent with accepted standards.

(1)(d) Determine that the probable benefits of the rule are greater than its probable costs, taking into account both the qualitative and quantitative benefits and costs and the specific directives of the statute being implemented:

The proposed amendments clarifies the intent and application of the code and brings the code closer to achieving the goals in RCW 19.27A.020(2) and RCW 19.27A.160. Specific details on each separate proposal having an economic impact are shown under Item I

(1)(e) Determine, after considering alternative versions of the rule and the analysis required under (b), (c), and (d) of this subsection, that the rule being adopted is the least burdensome alternative for those required to comply with it that will achieve the general goals and specific objectives stated under (a) of this subsection:

There are no alternatives to this procedure. If the rule is not adopted, this will be a violation of the State Law, which will affect the promotion of energy efficiency and safety in buildings consistent with accepted standards.

(1)(f) Determine that the rule does not require those to whom it applies to take an action that violates requirements of another federal or state law:

The primary objective of the Council is to encourage consistency in the building code throughout the state, and to maintain the building code consistent with the state's interest. The rule does not require those to whom it applies to take an action that violates requirements of another federal or state law.

(1)(g) Determine that the rule does not impose more stringent performance requirements on private entities than on public entities unless required to do so by federal or state law:

The adoption and amendment of the 2021 Washington State Energy Code, Residential Provisions, do not impose more stringent performance requirements on private entities than on public entities.

(1)(h) Determine if the rule differs from any federal regulation or statute applicable to the same activity or subject matter and, if so, determine that the difference is justified by the following:

☒This does not differ from any federal regulations or statute applicable to the same activity.

☐(1)(i) A state statute explicitly allows the agency to differ from federal standards; or

☐(1)(ii) Substantial evidence that the difference is necessary to achieve the general goals and specific objectives stated under (a) of this subsection; and

☐(1)(iii) Coordinate the rule, to the maximum extent practicable, with other federal, state, and local laws applicable to the same activity or subject matter.